

viously contaminated with *B. enteritidis* and heated for one hour at 100 degrees. Bahr and Dyssegard¹⁵ tested the toxicity of these organisms by injections of filtrates or boiled cultures. Geiger and Meyer,¹⁶ in a preliminary report, apparently have solved the technical difficulties. These authors record positive results when white mice are fed whole heated cultures. The symptoms appear in a few hours and death usually in twelve to twenty-four hours. The pathological picture described a distended duodenum, the hyperemic jejunum and ileum and the pleural effusion considered as pathognomonic for experimental food poisoning in mice. Rabbits, cats, and guinea pigs were not affected in the same manner, but a monkey did show symptoms when fed with ten cubic centimeters of a potent poison.

Experimentally, there appears to be no doubt that heat-stable poisons can be produced by a group of bacteria usually classified as causative agents in outbreaks of food poisoning. Reports of outbreaks in the United States from food alleged to contain heat-resistant bacterial poisons have been singularly lacking. Confirmation of one report, however, has been offered by Pryer.¹⁷ The recent preliminary report of Geiger and Meyer¹⁶ on experimental food poisoning appears to indicate that the white mouse is the most susceptible orally to certain bacterial poisons and, therefore, the logical laboratory animal for test purposes. It is quite possible that this laboratory phenomenon may be extended to include other bacteria not so well known in food poisoning. It does, indeed, throw further light on the production of this interesting clinical entity.

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INTUSSUSCEPTION—ITS ROENTGENOGRAPHIC DIAGNOSIS*

REPORT OF CASES

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AND

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IN recent years there have been found many new fields of usefulness in roentgenographic diagnosis; among these the recognition of intussusception, with occasional case reports, has appeared in the literature. However, the reports published indicate that in many instances the findings were those of intestinal obstruction, the exact diagnosis being made only as a result of surgical exploration or postmortem examination. A typical case of intussusception without complete obstruction presents definite diagnostic roentgenographic evidence of its presence and should be fairly easily recognized when the roentgenologist has become familiar with its appearance.

In cases of intussusception with acute intestinal obstruction the patient is critically ill, and immediate surgery too obviously indicated to permit any prolonged roentgenographic study to be made. Under these circumstances the roentgenologist should be content in diagnosing an obstruction and determining its approximate location without attempting to determine the nature of the obstructing lesion. This is easily done by taking a flat plate of the abdomen and pelvis preferably through a Bucky diaphragm, the diagnosis being based on a gas-distended bowel above the obstructed site.

INCIDENCE AND VARIETIES

Intussusception occurs most commonly in infants; over 60 per cent of the cases on record are in the first year of life. It is the most common cause of intestinal obstruction at this age. Holt reports 358 cases of intussusception, and Wichman was able to collect 724; the majority of these were in infants or children. Eliot and Corscaden have collected 300 cases in adults.

Intussusceptions may occur in any part of the gastro-intestinal tract, but those occurring at the ileocecal valve are by far the most common. Intussusceptions of the small bowel are called

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* Read before the Radiology Section of the California Medical Association at the Fifty-eighth Annual Session, May 6-9, 1929.

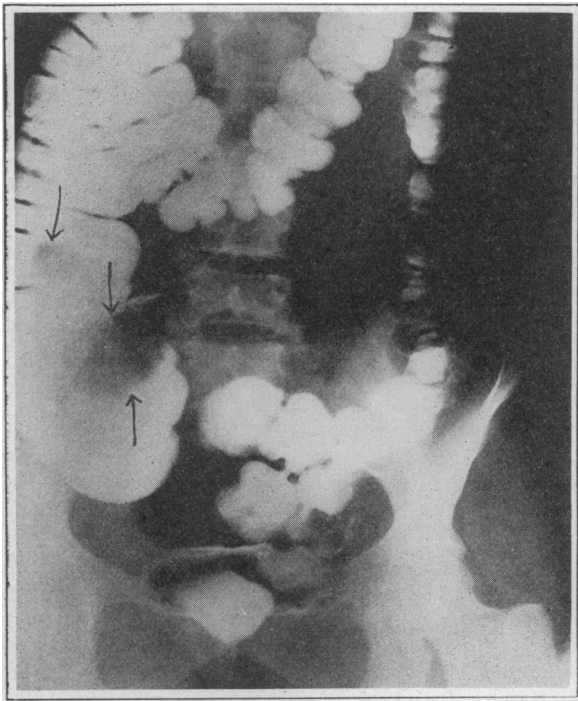


Fig. 1.—Barium Enema—Case 1. Note the central "gas-filled" filling defect in the cecum and ascending colon commencing at the ileocecal junction.

enteric; those of the colon, colic; and those at the ileocecal valve, ileocecal.

ETIOLOGY

Two important anatomic circumstances must be considered in relation to the causation of intussusception.

1. The difference in diameter of the small and large intestines.
2. An abnormal length and mobility of the mesentery.

The fact that there is an incompetent ileocecal valve in most infants may be a factor. Over one-third of the reported cases of intussusception in adults have been caused by tumors protruding into the lumen of the bowel; the tumor always being found at the apex of the intussusceptum. Both of the cases in the present report were caused by lymphosarcoma of the terminal ileum with polypoid growths protruding into the lumen of the bowel.

Meckels' diverticulum, the vermiform appendix, ulcers of the bowel and enlarged lymph nodes pressing on the wall of the small intestine are all mentioned as being the causes of intussusception. Increased peristalsis in infants is a common cause of intussusception, this usually being brought on by a change in diet.

PATHOLOGY

Intussusception is simply the invagination of one part of the bowel into the part continuous with it, either above or below. In the former case we speak of an ascending invagination, in the

latter of a descending one. Naturally the descending type is the more common. The portion of bowel acting as the cover is called the intussusciens, while the included part is the intussusceptum. The neck is that part of the bowel where the intussusceptum passes over into the intussusciens. The apex is the part of the intussusceptum projecting upwards or downwards into the bowel cavity. Double invaginations are occasionally seen in which an intussusception itself becomes a part of an additional invagination process.

The circulatory disturbances due to traction and compression of the mesentery are of the gravest importance, and are in direct relationship to the rapidity of onset and the tightness of the constriction. Venous stasis with exudation, infection, inflammation and even gangrene at the neck of the intussusceptum constitute the prominent points in the morbid anatomic sequence. In less intense degrees of strangulation adhesions may form between the peritoneal coats rendering the anatomic relations permanent. In such cases after the disappearance of the edema and constriction the intestine may again become patent. On the other hand sloughing of the entire intussusceptum may lead to spontaneous recovery. This occurs only rarely in children, but is fairly common in adults. Wichman found sixty-eight such cases in his series.

CLINICAL FINDINGS

The symptoms and physical findings in intussusception are so well known that only a brief summary will be given here. Onset is sudden with severe cramping pain and vomiting; the pain occurs paroxysmally every few minutes. In cases with obstruction there may be one or two

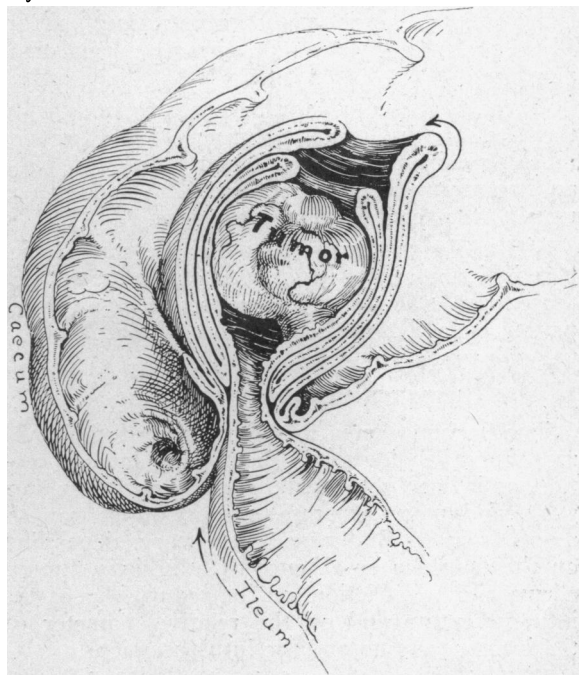


Fig. 2.—Sketch of the surgical findings, Case 1. Note the double intussusception with a tumor mass protruding into the lumen of the bowel. Compare with Fig. 1.

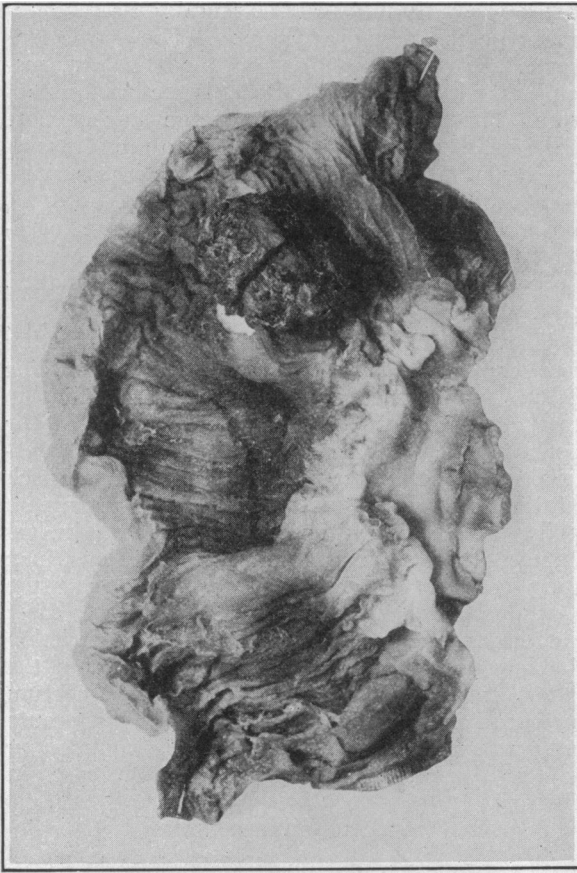


Fig. 3.—Photograph of the resected bowel showing the pedunculated tumor mass. At biopsy this was found to be a lymphosarcoma.

loose bowel movements and then only blood, or blood and mucus are passed. Bowel movements are accompanied by marked tenesmus. With these symptoms there is noted prostration, pallor, feeble pulse and a normal or nearly normal temperature.

There is a palpable tumor corresponding to the site of the intussusception. This becomes more prominent during the paroxysms of pain, an important diagnostic point. The abdomen is usually relaxed between paroxysms.

If the obstruction is complete, the clinical picture is that of acute ileus, but even in these cases there may be found a localized tenderness on palpation over the intussusception and at times a palpable mass.

ROENTGENOGRAPHIC FINDINGS

The barium enema is the method of choice of most roentgenologists in diagnosing intussusception, as it does not interfere with emergency surgery, and more accurate interpretations can be made from its findings. These vary, depending on the presence or absence of adhesions, tumor, edema and constriction, on the reducibility of the intussusceptum and on the relative diameter of the intussusceptum and the intussusciens.

Early in the course of the disease, before adhesions are formed, there is noted a temporary obstruction to the flow of the barium at the apex

of the intussusceptum but by change of position, rotation and maintenance of pressure the barium can be made to pass peripherally about the intussusceptum, leaving a central, gas-filled, filling defect. See Figs. 1 and 5.

After the formation of adhesions or with marked edema there is a complete obstruction to the flow of the barium. However, in these cases there is noted a cupola or a "U"-shaped deformity formed by the apex of the intussusceptum which at times contains gas, a filling defect not commonly observed in other lesions causing obstruction. See Fig. 6.

Karshner, in a personal communication, states that in one case of intussusception at the Children's Hospital the barium enema was successful in reducing the intussusception. In this instance the child's life was undoubtedly saved, as it was admitted to the hospital because of a bronchopneumonia and developed the intussusception while in the hospital. There has been no recurrence of the trouble, although several months have elapsed. Ashbury cites a similar case, but raises the point that surgery should be resorted to despite the reduction, as there is apt to be a recurrence.

Naturally in enteric intussusception the barium enema is of no value, but as these comprise less than 30 per cent of the total number of cases, a normal colon on fluoroscopic examination, together with a flat plate of the abdomen, should exclude the more common types.

Groedel and Altschul each report a case of intussusception in which the barium enema failed

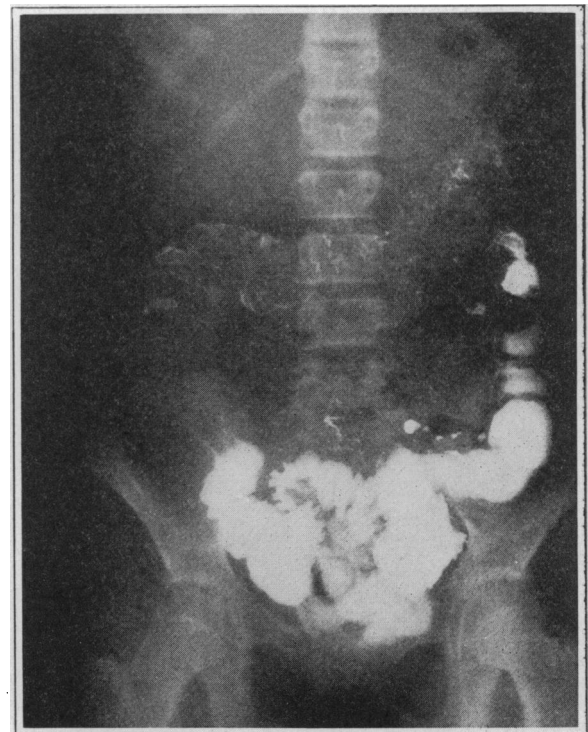


Fig. 4.—The six-hour motor meal study—Case 2. In this film there is an apparent absence of the cecum and part of the ascending colon, the barium showing as a narrow tubular tract.

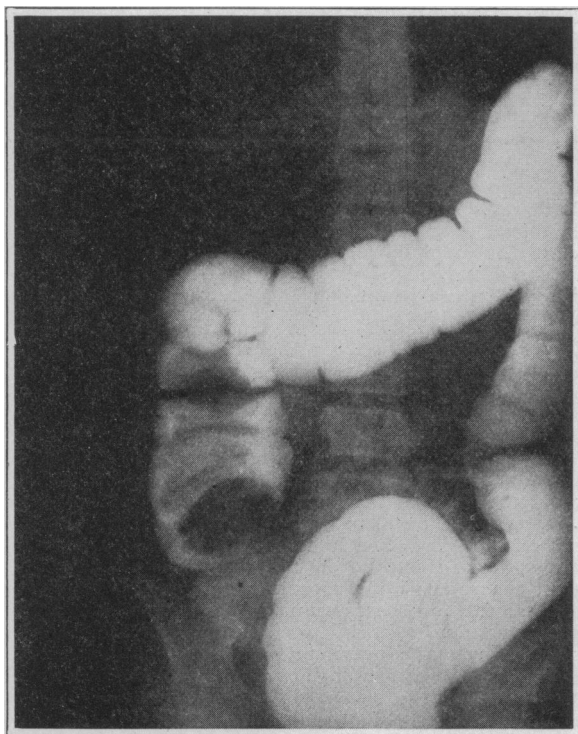


Fig. 5.—Barium Enema—Case 2, September 16, 1926. This illustrates very well the central gas-filled defect observed in the early stages of intussusception before the formation of adhesions.

to show evidence of lesion, the diagnosis being based on a motor meal study. In Groedel's case the roentgenographic findings were not at all characteristic, suggesting an ileocecal stenosis rather than an intussusception. Altschul's findings in the motor meal study are in accord with those noted in one of our cases in which there was an apparent absence of a segment of bowel. In the six-hour examination the head of the barium meal had reached the descending colon. In the region where one would normally expect to find the cecum and ascending colon the barium showed as a narrow tubular tract without the usual bowel form or normal haustra. Beyond the hepatic flexure haustral indentations again appeared. See Fig. 4. In Altschul's case there was the same narrowed barium-filled bowel (the intussusceptum); surrounding this was the intussusciens which was visualized as it contained gas. The borders of the intussusciens showed definite haustral markings. In view of these findings it is difficult to explain the absence of positive roentgenographic evidence of intussusception in the barium enema.

REPORT OF CASES

CASE 1.—Miss H. C., thirty-two years of age, was admitted to St. Vincent's Hospital complaining of severe colicky pain in the lower abdomen of about two weeks' duration. These pains came on in attacks and were relieved by application of heat to the abdomen or by enema. The pain had no relationship to meals, menses or urination. She had been able to work until three days before admission, when the pain became very severe and seemed to settle in the right lower quadrant.

At this time she first noticed a mass in her right side. The mass was tender and quite hard during the attacks of pain, but seemed to become softer between attacks. The patient stated that she felt sure the mass changed position from time to time. Patient had had fairly normal bowel movements throughout her illness. She had had a similar attack of pain several weeks prior to onset of present illness; this, however, lasted only a few hours. Patient was nauseated but did not vomit.

It is interesting to note that the patient had had an appendectomy performed in 1925. At this time symptoms were typical of an acute appendicitis, the biopsy of the removed appendix confirming these findings. The patient was apparently completely relieved from symptoms for over two years.

Physical Examination showed a well developed and well nourished young woman. The abdomen was slightly distended and there was a moderate muscle spasm on deep palpation. There was also noted an irregular mass in the right lower quadrant. Pressure on the mass caused a return of the cramp-like pains. Pulse 90, respiration 20, temperature 99.1 degrees Fahrenheit. Blood count: white blood cells 6837, polymorphonuclears 68 per cent, lymphocytes 30 per cent, red blood cells 4,720,000, hemoglobin 80 per cent.

Roentgenographic Findings: A "flat" roentgenogram was made of the abdomen to rule out acute intestinal obstruction in view of the history of appendectomy. There was no gas in the small bowel. The cecum and ascending colon both contained some gas, but they were not markedly distended and both showed normal haustral markings.

Barium Enema: There was no obstruction to the flow of the barium at any point and the contour of the colon was normal throughout. However, there was noted a central gas-filled filling defect extending from the ileocecal juncture up into the ascending colon for a distance of six to seven inches. On rotation of patient and on palpation, this gas shadow remained

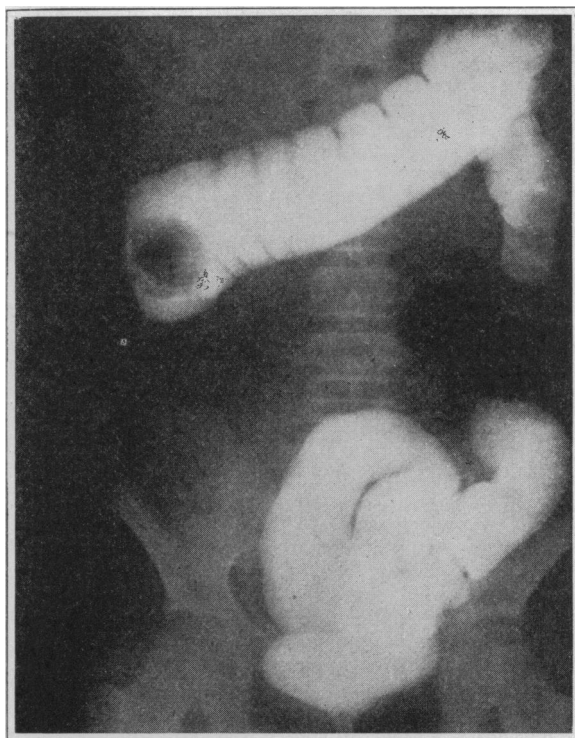


Fig. 6.—Barium Enema—Case 2, September 25, 1926. At this time adhesions had formed between the layers so barium could not be forced around the intussusceptum. This is a good illustration of the cupola filling defect noted by many writers.

constant, which one would not expect if it were free gas in the colon. At the ileocecal juncture this gas shadow resembled a finger-like projection into the cecum. See Fig. 1. A diagnosis of intussusception was made on the basis of these findings and immediate laparotomy advised.

Surgical Findings: In opening the abdomen the cecum was found to be moderately enlarged. On palpation a mass was felt within its walls, and the small bowel was invaginated into the cecum through the ileocecal valve. By making traction on the small bowel and pressure from above the mass, about six inches of the bowel was drawn out. At this point a second mass was felt obstructing the opening. This finally was pushed through the ileocecal valve with some difficulty. Examination disclosed a second intussusception surrounding a small hard tumor mass. This portion of the ileum was resected and an end to end anastomosis done. See Fig. 2. On opening the ileum there was noted a small round tumor about two and one-half centimeters in diameter projecting into the lumen of the small bowel at a point about seven inches above the ileocecal juncture. See Fig. 3.

Biopsy Report: "The tumor is composed of large lymphocytic cells round or oval in form with oval nuclei and granular chromatin. Many of the nuclei are hyperchromatic and a great many are undergoing mitosis. There is no evidence of an alveolar arrangement of the cells. The tumor is evidently a rapidly growing sarcoma, probably a large celled lymphosarcoma, arising from the lymphoid tissue of the bowel."

Patient had an uneventful convalescence following the operation and gained rapidly in general health, going back to work within a month. There was no recurrence of the pain noted prior to operation. A series of x-ray treatments was given for several months—despite these a tumor mass appeared in the right lower quadrant and grew steadily in size. She then failed rapidly, losing both in weight and strength, and died on July 11, 1928. At the time of her death the whole abdomen was filled with a large irregular-shaped nodular mass. No axillary, inguinal or cervical lymph nodes were palpable at any time and the lungs were free from metastases.

Comments: This case is interesting from several different aspects. *First*, the double intussusception of the terminal ileum, the primary cause being a small tumor mass projecting into the lumen of the bowel. *Second*, the fact that x-ray therapy had no appreciable result on the recurrence and growth of the tumor, whereas ordinarily lymphosarcoma is unusually susceptible to radiation therapy. *Third*, the operation for the subacute appendix two years prior to onset of symptoms. The biopsy of the removed appendix showed it to be subacutely inflamed and the patient made a complete recovery following the operation. In all probability the intussusception was not present at the time of this operation.

CASE 2.—Sophia B., a school girl, thirteen years of age, was admitted to the Pasadena Hospital complaining of nausea and colicky pain in the upper abdomen referred to the back. Her temperature was 99 degrees Fahrenheit, and the pulse ranged from 95 to 120. Bowels were irregular but the stool fairly normal in appearance. On palpation there was a poorly defined tender mass in the region of the ascending colon. The mass varied somewhat in size and definiteness from day to day. The appendix had been removed about six weeks previously in a Los Angeles hospital. At that time she was having symptoms similar to the symptoms on admission, and had a white count of 16,000. Preoperative diagnosis had been acute appendicitis, but when the appendix was removed it showed less pathology than was expected. Numerous mesenteric lymph nodes were palpated and when the patient had a recurrence of her symptoms a few days after the appendectomy her surgeon was convinced that the condition was one of tuberculous mesenteric

glands. The first x-ray examination was done September 15, 1926. The preliminary roentgenograms of the urinary tract failed to show evidence of opaque calculi, and the fluoroscopic examination of the chest revealed no demonstrable lesion. The stomach and duodenal cap were normal. At the six-hour examination the head of the barium column had reached the descending colon. In the region where one would normally expect to find the cecum and ascending colon the barium showed as a narrow tubular tract without the usual haustral indentations or bowel form. Beyond the hepatic flexure haustral markings again appeared. See Fig. 4. In twenty-four hours practically all the barium had been evacuated.

Barium Enema: There was no obstruction to the flow of the barium from the rectum to the hepatic flexure; here obstruction was encountered, but by change of position, manipulation and maintenance of pressure the barium was made to pass peripherally about the intussusceptum, which left a characteristic, central, gas-filled defect within the outline of the ascending colon. The "U"-shaped or conical defect about the head of the intussusceptum was also nicely demonstrated both in the fluoroscopic examination and on the films. See Fig. 5. The second motor meal study showed barium in the terminal ileum to the point where the intussusceptum entered the intussusciens; the intussusceptum contained gas and practically no barium; while a thin layer of the barium enema given the previous day filled the peripheral region of the ascending colon about the intussusceptum.

Patient refused operation and although she had attacks of colicky pain there was a daily bowel movement. Eight days later a third enema was given. At this time the barium passed only as far as the hepatic flexure as adhesions had developed between the two layers so that no barium could be forced around the intussusceptum. However, the findings were still characteristic with the typical gas-filled, cupola, filling defect caused by the head of the intussusceptum. See Fig. 6. Consent to operation was now obtained and the abdomen opened October 2, 1926. The surgical report is as follows: "The ileum was intussuscepted into itself and then through the ileocecal valve and into the ascending colon. A tumor in the wall of the ileum nine inches from the ileocecal valve was evidently the head of the intussusceptum and the cause of the invagination. The intussusception was successfully reduced. There was no effort made to remove the tumor because of the presence of many mesenteric lymph nodes. An anastomosis was done between the ileum and the transverse colon just beyond the hepatic flexure." Following the operation the patient gained rapidly and soon presented a normal appearance. However, this improvement was only temporary, for she returned to the hospital within six months complaining of a tumor mass, anemia and hemorrhage from the bowel. She died April 21, 1927. The postmortem examination showed the condition to be a lymphosarcoma arising from a Peyer's patch with the greatest involvement in the last ten inches of terminal ileum. The thymus was much enlarged.

COMMENT

This second case illustrates very well practically all of the various roentgenographic characteristics of intussusception as described in the literature.

1. The "cupola" effect produced by the head of the intussusceptum.
2. The central, gas-filled, filling defect.
3. The thin track of barium through the intussusceptum.
4. The apparent absence of one segment of the bowel; in this case the cecum and ascending colon.

5. The annular defect at the beginning of the intussusceptum.

As in Case 1, there had been an appendectomy performed prior to the discovery of the intussusception.

In both of these cases the primary cause of the intussusception was a lymphosarcoma protruding into the lumen of the bowel. In this connection Ewing's description of lymphosarcoma of the intestine is of interest. He states that lymphosarcoma of the intestine is an important type of the disease, occurring most commonly in the ileum. There are two kinds—one with central ulceration and formation of adhesions, the other with polypoid growths protruding into the lumen of the bowel. Metastases occur early in the regional lymph nodes and may extend to many organs. Acute cases resemble appendicitis.

CONCLUSIONS

In intussusception with acute obstruction an extensive x-ray examination is unnecessary and not to be advised. In chronic intussusception the roentgenographic findings vary, depending on the degree, permeability and duration of the invagination, the amount of constriction, presence of edema, adhesions, etc. They are as follows:

1. The *barium enema* early in the course of the affection is characteristic. There is a momentary obstruction to the flow of the barium, but by change in position, manipulation and maintenance of pressure, barium can be made to pass around the intussusceptum leaving a central gas-filled defect.

2. The barium enema after formation of adhesions is equally characteristic. There is then noted a complete obstruction to the flow of the barium—the head of the enema having a characteristic "U" or cupola shape, a filling defect not commonly observed in other lesions causing obstruction. The apex of the intussusceptum may contain gas.

3. The motor meal study may show:

- (a) An apparent absence of one segment of the bowel—usually the cecum or ascending colon.

- (b) A thin track of barium as it passes through the intussusceptum.

- (c) An annular filling defect at the neck of the intussusceptum.

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DISCUSSION

ORVILLE N. MELAND, M. D. (1407 South Hope Street, Los Angeles).—Obstructive intestinal lesions, whether acute or chronic, have always been difficult of diagnosis, as regards etiology.

The present publication by Davis and Parker is a distinct contribution since it gives definite roentgen signs as seen in incomplete obstruction due to intussusception. It is impossible to base a diagnosis upon the roentgen signs, but they do give the surgeon an opportunity to be prepared in advance for the condition he is to encounter. He will know exactly where

to make his incision and he will know that he is dealing with an intussusception.

From a pathologic standpoint it is extremely interesting to see that, in both the cases reported, a primary intestinal lymphosarcoma was the cause of the clinical symptoms. Lymphosarcomata are always extremely difficult to handle and these cases were no exception to the rule, for neither surgery nor radiation gave anything but temporary relief. It is conceivable that with earlier diagnosis, through methods as outlined by the authors, the condition may be diagnosed and treated before it has become disseminated.

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HENRY SNURE, M. D. (1501 South Figueroa Street, Los Angeles, California).—The authors are to be congratulated on their case reports and the thorough description of the type of intussusception that can be definitely diagnosed by roentgen ray examination. Usually this type of case occurs in the older patient where the percentage of intussusception is less.

Muff, in his case report, mentions another type of filling defect, namely the narrow lumen of barium filled intussusceptum passes through a rose petal shadow, formed by the gas-filled haustra of the ascending colon being crowded together. The same type of rose petal shadow was reported by Karewski in the descending colon in a chronic case where the intussusceptum had progressed to that point. Illustrations of Czepa's case show the apex of the intussusceptum lying in the midportion of transverse colon with crowding together of the gas-filled haustra but no rose petal formation. Stierlin reports cases with roentgenologic shadows similar to Case 1, associated with tuberculosis of the intestine. When tuberculosis was present, the cecum was never displaced upward as is so often the case in other types of intussusception. He also mentions cases of long, narrow, barium-filled lumina in the cecal area, quite smooth in outline and associated with a sausage-shaped mass, that were caused by carcinoma. However, carcinoma usually is irregular in outline, the surrounding gas shadow of the intussusciens is absent and occurs only in the older patients.

The roentgenologic examination does not lose its value in intussusception even when the typical findings presented in the two case reports are absent. The plain film and the barium enema will suggest complete or partial obstruction and indicate surgical intervention as the method of treatment.

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KARL M. BONOFF, M. D. (1930 Wilshire Boulevard, Los Angeles).—The authors of this paper are to be complimented on adding to the literature and our ability to diagnose a not uncommon clinical entity. The earlier a diagnosis is established, the better will be the surgeon's result. Practically no time is lost in the acute case by first taking an ordinary or "scout" film of the abdomen as suggested by the authors, and this should be done as a routine procedure in any vague abdominal condition.

One thought that occurs is that possibly both patients complained of some abdominal disturbance prior to their acute attacks, and that a complete gastro-intestinal study would have resulted in a diagnosis of the presence of a tumor mass. This might have prevented the intussusception and the resultant emergency, if at least the pathology had been of any other type of malignancy than lymphosarcoma.

The only case (a child of two years of age), that I personally can recall having made a diagnosis of intussusception upon was similar to Doctor Karshner's, in which a "scout" plate definitely suggested obstruction at the ileocecal valve and upon the administration of an opaque enema the typical findings were present, but an overzealous attempt to fill out the cecum by manipulation resulted in a reduction of the invagination.